ISSN 2664-4150 (Print) & ISSN 2664-794X (Online)
South Asian Research Journal of Engineering and Technology
Abbreviated Key Title: South Asian Res J Eng Tech

| Volume-5 | Issue-3 | May-Jun- 2023 | **DOI: 10.36346/sarjet.2023.v05i03.003**

Original Research Article

A Novel Automatic Approach for Detection of COVID-19 using Double Deep Neural Networks with X-ray Images

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Article History
Received: 02.05.2023
Accepted: 08.06.2023
Published: 27.06.2023

Abstract: Elderly persons and patients with chronic illnesses are mostly affected by the pandemic disease Covid which also claims lives. It has terrible implications on daily living, public health, and the global economy. Finding positive examples as soon as feasible is difficult. There are only a certain amount of covid test kits available because of the daily rise in cases. Implementing an autonomous detection system as a speedy alternative diagnosis option is essential to stopping the future spread of this epidemic and to treating afflicted persons as soon as possible. Combining radiological imaging with the use of cutting-edge AI tools can be beneficial for the precise diagnosis of this illness and can also help distant areas who lack expert medical care to find a solution. In this project, we have used double deep neural networks to develop an automatic detection of Covid (Convolutional-Neural-Network model, VGG-16 model). Covid chest X-rays will be used as the history data. It will be determined whether the chestX-ray image is covid positive or covid negative.

Keywords: Covid-19, Convolutional Neural Networks, VGG-16, Patients, Chest X-ray images.

INTRODUCTION

The covid-19 illness was initially discovered in china and distributed over the globe from china. In the fourth quarter of 2019, the WHO has classified it as a pandemic disease due to its rate of spread. By the end of 2020, WHO stated that there were over 45 million patients globally and that the death toll had surpassed one million in just over a year and was rising daily [1]. The common signs include cough, fever, and exhaustion. Skin rashes, pains aches, a sore throat, diarrhea conjunctivitis, headaches, loss of odour or flavor, and a changes in the color of the toes or fingers are also some of the symptoms. If infected people aren't kept apart they could spread the illness to others. Techniques like quarantine and isolation are beneficial in halting the propogation of viruses. Reverse-Transcription-Polymerase-Chain-Reaction, Rapid-Antigen-Test are available for testing to check if the patient is contaminated or not, Nevertheless, these are expensive and time intensive [2, 3]. Ct-scans and chest-x-rays are two common imaging methods. X-ray scan-images are accessible also more affordable than ct- scans. An x-ray can reveal damaged organs like the lungs. In addition to infections, pneumonia, tumours and others. These advantages make x-ray pictures a useful tool for predicting covid-19 patients. X-ray pictures will be categorized as covid or normal utilizing deep-transfer-learning strategies and trained models [4].

MATERIALS AND METHODS

1. Dataset Collection

We used a combination of two-datasets to conduct trial (experiments) with different deep-neural-networks (CNN, VGG16). The first dataset entitled "Covid chest X-ray dataset" presently it contains 3000 covid19-positive

images [5]. Another dataset entitles "Pneumonia-dataset" from the Kaggle it contains 6000 covid-19 negative. Further X-ray images will be added according to the requirement to avoid fitting problems.

2. Data Pre-Processing

Images are converted into grey scale. Usually, BGR consists three-channels where as grey-scale consists of one-channel. We have preferred grey-scale over BGR as it reduces model complexity. Image is converted into matrix form where each pixel has a value from 0 (black) to 255 (white). The possible range of pixel values depend on the colour depth of the image. Resizing the gray scale into 100*100 is done, since we need a fixed common size for all the images in the dataset. And then these steps are applied for the data [6].

2.1 Binary threshold

A predetermined threshold value is used to compare each pixel's value. Set to zero if the pixel value exceeds the threshold; otherwise, use the maximum intensity value (255). Thus, a binary format conversion of the input greyscale image is performed.

2.2 Background noise removal

This phase is used to eliminate irrelevant intensity data. These inconsequential intensities are just noise [7]. The photos are divided into related segments. Any connected component whose size is 500 pixels or less is deleted by setting the value to zero.

2.3 Feature normalization

When determining the relative importance of image pixels, normalising the feature's value is crucial [8]. The cost function's smooth convergence is another benefit of normalisation. The input volume is normalised in the suggested model using the min-max scaling method. The range of the normalised pixel value is [- 0.5, 0.5].

2.4 Label encoding

In this step, label encoding is done on the row cleaned data. This step is necessary as the data that is being dealt with is categorical data, and they need to be assigned a numerical label as the training model can understand only numerical values. Moreover, label encoding helps in identification of the categorical values.

3. Building the models

In this step, CNN and VGG-16 base models are created. Different layers such as flattening, dense, dropout will be added and "RELU" activation functions are applied to increase the accuracy.

4. Dataset split

Here, 70% of the data is taken as training data and 30% of the data has been taken as testing data.

5. Model Training

The training data is now fit into the various models and the outputs are predicted. The accuracy metrics are derived based on the outcome of the predictions.

6. Covid Prediction

Now, to test the accuracy of the model, sample data is given fed to the system. The result is given in the form of a message, which tells if the person is suffering or not.

7. User Interface

Created a user-interface using flask and connecting this to model.

Algorithms used

1. Tensor flow

The open-source-library Tensor is used for deep-learning and machine-learning. Although it can be used for a wide-range-of-tasks, deep-neural-network training and inference are given particular attention [9, 10]. Its main applications include classification, perception, comprehension, discovery, prediction, and creation. TensorFlow 2 places a strong emphasis on usability and simplicity with features like eager execution, perceptive higher-level APIs, and adaptable modeldevelopment across all platforms.

2. Keras

KERAS is a Programming interface intended for individuals, not machines. It gives a clear and reliable variety name. Programming interface, it gives clear and unprejudiced blunder messages, and it diminishes the quantity of client activities expected for normal use situations [11]. Keras has various instruments that make working with picture and text

information more straightforward and decrease how much exertion expected to compose profound brain network code. These devices incorporate different executions of generally utilized neural network building blocks like layers, goals, enactment capabilities, and enhancers.

3. Flask

Flask is a compact and adaptable framework that offers tools and utilities to developers so they may make web applications quickly and efficiently. When building online applications, Flask offers a straightforward and user-friendly interface with integrated support for managing HTTP requests and answers, routing, and URL management. Additionally, it supports templating and offers a straightforward method for creating HTML pages dynamically from user input [12-14].

4. CNN

A common application of ann of the cnn type in deep learning, also known as layers of perceptrons, is the analysis of visible data using divide-weight convolution substance or filters that produce characteristic matches responses that are translation-equivariant by sliding through input features [15]. By utilising the hierarchical structure in the data and creating patterns of growing using lesser and simple designs to increase complexity imprinted in its filters, these channels' total connectivity makes them susceptible to data over-fitting [16-18]. Instead of manual engineering as in earlier systems, CNNs use a novel regularisation technique that places CNNs at the bottom of a scale of connectedness and complexity.

We have used a sequential model from the Keras library to create the CNN model [19]. The layers will be added one after the other to create the convolutional neural network. A total of 128 filters, with three parallel kernels are applied of sizes [3,3],[5,5],[7,7] to extract the features, due to which the dimension of the matrix image will be reduced. And then, conv2D layer is added with 64 filters and the MaxPool2D layer's pool size must be set to (2,2), that will choose the highest value from each section of the picture that is 2 x 2 pixels [20, 21]. By doing this, the image's dimension will reduce by a factor of 2. After that, again a conv2D layer is added with 32 filters and the MaxPool2D layer's pool size must be set to (2,2). Flattening layer is added on top of that. We must keep the dropout rate in the dropout layer at 0.5, that indicates 50% of neurons are eliminated arbitrarily. We reapply these three layers with a few modifications to the settings. Activation functions such as ‘relu’, ‘softmax’ are used.

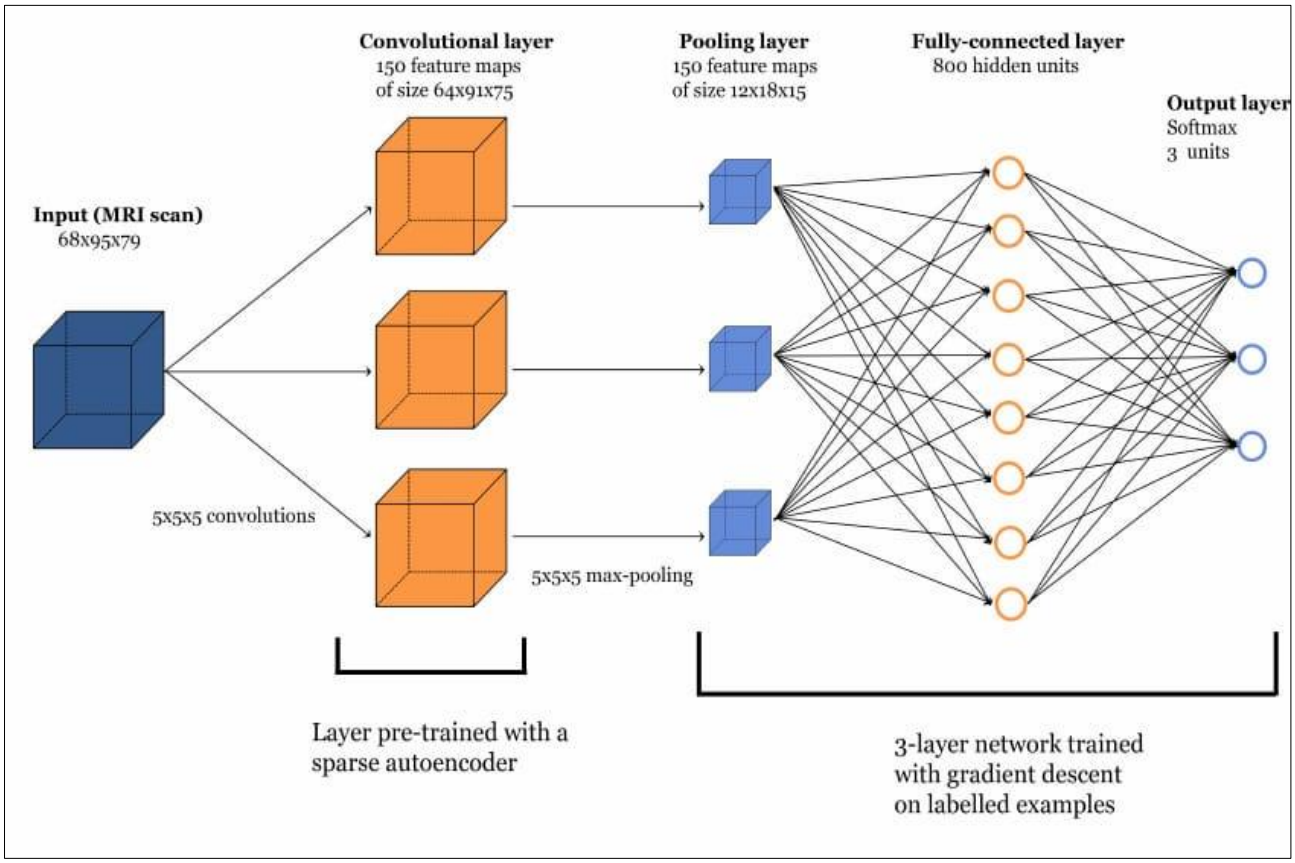

Figure 1: CNN Model

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 model (Functional)          (None, 100, 100, 384)     11008

 conv2d_3 (Conv2D)           (None, 98, 98, 64)        221248

 activation (Activation)     (None, 98, 98, 64)        0

 max_pooling2d (MaxPooling2D  (None, 49, 49, 64)       0
 )

 conv2d_4 (Conv2D)           (None, 47, 47, 32)        18464

 activation_1 (Activation)   (None, 47, 47, 32)        0

 max_pooling2d_1 (MaxPooling  (None, 23, 23, 32)       0
 2D)

 flatten (Flatten)           (None, 16928)             0

 dropout (Dropout)           (None, 16928)             0

 dense (Dense)               (None, 128)               2166912
...
Total params: 2,426,018
```

Figure 2: Customized CNN Model Construction

5. Vgg-16

Convolutional and pooling layers of the vgg16 algorithm are used to identify covid in a patient. VGG-16 is an object identification and classification method. It is a well-liked technique for classifying images and is simple to employ with transfer learning. The 16 in vgg16 stands for 16 weighted layers. Thirteen convolutional layers, five max pooling layers, three dense layers and a total of 21 layers make up VGG16, but only sixteen of them are weighted layers, also known as learnable parameters layers. Input tensor size for VGG16 is 224,244 with 3 RGB channels [22-24]. The most distinctive feature of VGG16 is that it prioritised convolution layers of a 3x3 filter with stride 1 rather than a large number of hyper-parameters and consistently employed the same padding and maxpool layer of a 2x2 filter with stride 2.

Throughout the whole architecture, the convolution and max pool layers are uniformly ordered. There are 64 filters in the conv-1 layer, 128 filters in conv-2, 256 filters in conv-3, and 512 filters in conv-4 and conv-5. Vgg can capture spatial correlations in cxr regions of interests(roi) by employing an attention module the categorization is fine-tuned using the appropriate convo layer, 4th pooling layer [25, 26]. Pooling layer is selected as a suitable layer since it not only performs well in deep learning model training tasks but also has good discriminability for cxr images. Less parameters are required because the model uses the correct convo or pooling-layer. This pooling-layer catches the fascinating information that can be found in cxr pictures, which makes it easier to quickly identify and diagnose most lung-related disorders like covid 19 [27].

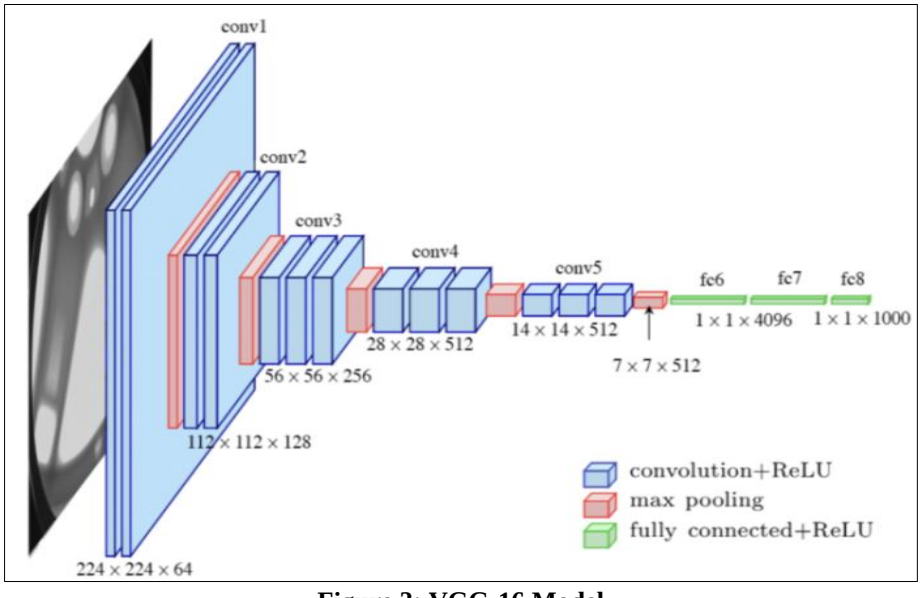

Figure 3: VGG-16 Model

RESULTS

We have compared our customized CNN with the best model which is VGG-16 and we have observed that our model gave us an accuracy of 95% where as VGG-16 gave us an accuracy of 95.5% which is very close to our model.

```
print(model.evaluate(test_data,test_target))

61/61 [==============================] - 84s 1s/step - loss: 0.1790 - accuracy: 0.9506
[0.17899809777736664, 0.9506236910820007]
```

Figure 4: Accuracy

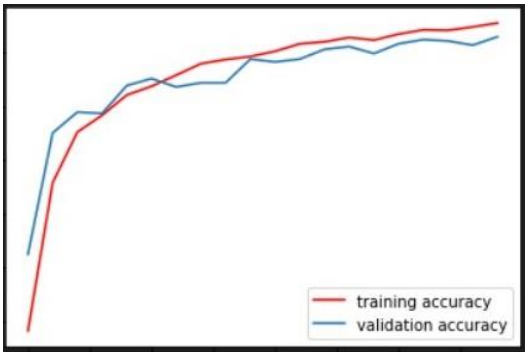

Figure 5: training and validation accuracy

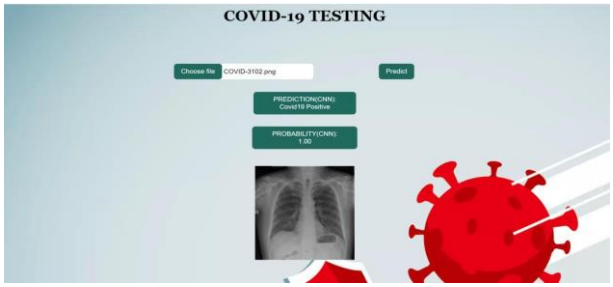

Figure 6: Testing positive sample

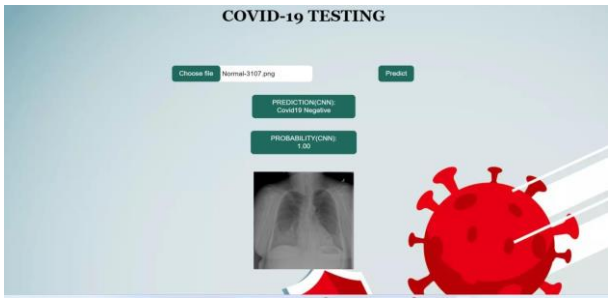

Figure 7: Testing negative sample

CONCLUSION

From limitations we have seen that the VGG-16 gives us the maximum accuracy but required high graphics resources and takes large amount of time for the training. So the customized CNN better because it is also giving maximum accuracyand does not have any compatability issues.

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